Psychological barriers in Asian markets

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Biographical note

Margarida Couto was born in Trofa, Portugal in February 28^{th}, 1993. She received her bachelor degree in Economics from Faculdade de Economia do Porto in 2015. In the same year she joined the Master in Finance at the same university, in which she is currently studying.

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Abstract

Psychological barriers are one of the many pricing effects that have been detected in financial markets. These barriers consist in the difficulty that some investors have to cross certain price levels. Their existence is spread to almost all types of markets such as the equity market, commodity market, option market, foreign exchange market and even the bond market. This study intends to test the existence of psychological barriers in Asian stock markets as well as to compare in this region, emerging markets with developed markets. To do so we will analyse the equity markets from China, South Korea, Taiwan, Hong Kong, Japan and Singapore. The objective of this study is to contribute to the literature in what concerns market efficiency hypothesis and also investors' rationality. Besides this, the impact on general price levels of stock markets is also of particular interest. In terms of practicability, the findings of this paper can be used to create profitable strategies for investors. So, after using uniformity tests, barrier tests and analysing conditional effects on returns and variances we proved the existence of psychological barriers in Asian stock markets. The time period analysed matches the start of each index and ends in the 31st December 2016 for all indexes. We found consistent evidences of psychological barriers in Taiwan and South Korean's stock market. The remaining indexes show no clear pattern across methods, which means that our findings are inconclusive.

Key-words: Psychological barriers; M values; Asian developed markets; Asian emerging markets

JEL-Codes: G14, G15

Resumo

As barreiras psicológicas são um dos muitos efeitos de preços que se podem encontrar nos mercados financeiros. Estas barreiras consistem na dificuldade que alguns investidores têm em ultrapassar certos valores. A existência destas barreiras está espalhada por quase todos os tipos de mercados inclusive os mercados accionistas, mercados de bens, mercado de opções, mercado cambiais e até mercados de obrigações. Assim, este estudo pretende provar a existência de barreiras psicológicas nos mercados acionistas asiáticos assim como comparar, nesta região, os mercados emergentes e desenvolvidos. Iremos então analisar os mercados da China, Coreia do Sul, Taiwan, Hong Kong, Japão e Singapura. Relativamente ao objetivo deste estudo, este tem como propósito contribuir para a literatura no que respeita à teoria da eficiência dos mercados e racionalidade dos investidores. Além disso, o impacto que estas barreiras podem ter no nível geral de preços de um determinado índice é de particular interesse. Em termos práticos, as conclusões deste estudo podem ter um papel importante na criação de estratégias lucrativas por parte dos investidores. Desta forma, utilizando testes de uniformidade, testes de barreira e analisando os efeitos condicionais na média e variância vamos provar a existência de barreiras psicológicas nos mercados acionistas asiáticos. O período de análise será o início de cada índice e o término será o dia 31 de Dezembro de 2016 para todos os índices. Concluímos que de facto as barreiras psicológicas existem e podemos encontrá-las de forma consistente nos mercados de Taiwan e Coreia do Sul. Quanto aos restantes índices, não conseguimos encontrar um padrão sólido ao longo dos vários métodos, que indica resultados inconclusivos.

Palavras-chave: Barreiras psicológicas; valores M; mercados asiáticos emergentes; mercados asiáticos desenvolvidos

Códigos-JEL: G14, G15

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1. Introduction

Psychological biases are very common nowadays on financial markets. The amount of reports on the finding of these biases is very large and in fact supported by studies conducted by several authors (e.g. Bahng, 2003). Particularly, psychological barriers that are a reflection of investor's feelings and moods when investing emerged across almost all markets. These barriers consist in the difficulty that some investors have to cross certain price levels. This bias was reported in the equity market, commodity market, option market, foreign exchange market and bond market and in different regions of the globe, such as Europe, America and even Asia. The focus of this paper is to study the existence of psychological barriers in Asian markets as well as its impact on theories such as EMH (efficient market hypothesis) and investors' rationality. Besides this, the analysis will be done comparing emerging Asian markets and developed Asian markets. It is assumed that investors working in a developed market would be better informed and more rational (Woodhouse *et al.*, 2016).

The paper produced by Bahng (2003) gave to the financial community some insight of the existence of psychological barriers in Asian stock markets. Giving that much time has passed since his study it is now necessary an update on this phenomenon in this specific region. According to the occurrences of the last decade such as 2008 global crisis, the crash in the Chinese stock market in January 2016, the increasing competition of Asian countries in what concerns production and the fall of Chinas' competitiveness it is important to study this region for the extant of psychological barriers once again. Moreover Dorfleitner and Klein (2009) stated that once an anomaly is found it tends to disappear in the future. However, recent news on Asian markets continues to show that psychological barriers still exist.

"Nikkei surges to six-month closing high above 17,200" - The Japan Times, October 20th 2016

The discussion on the effects of resistant and/or support levels in market efficiency and investors' rationality is also something that arises with the findings of this psychological bias. Donaldson and Kim (1993) consider that the existence of psychological barriers is not a contradiction to market efficiency however they think that investors are not fully rational. Dorfleitner and Klein (2009) believe that the presence of barriers can be seen as market anomalies and thus an argument against market efficiency hypothesis and rational investors. Also Bahng (2003) believes that his findings on the Taiwanese stock market are consistent with market inefficiency, once their study was conducted assuming that investors act irrationally and emotionally when investing. Not only we will contribute to these main questions but also the aim of this study is to help investors' find profitable strategies once we find the presence or not of barriers.

The research will be done using five different psychological detection methods. First, we will perform a uniformity test based on the assumption that the M- values follow a uniform distribution in the absence of psychological barriers. M-values are characterized as the last two digits in the integer portion of a certain price. Afterwards, we will run a barrier proximity test, that assesses the tails of the M-values' distribution and a hump shape test that focus on the entire distribution. Finally, the tests of behaviour of returns that evaluates the changes in conditional means and variances of daily index returns around presupposed barriers and also notes if a psychological barrier is being approached from above or below. These analyses will be done in six Asian stock market indexes from China, Korea, Taiwan, Hong Kong, Japan and Singapore that are the areas from East Asia that appear in the MSCI ACWI Index. The first three represent emerging areas and the final three developed areas. Furthermore, this selection will help us to perform a comparison between emerging areas and developed areas once, usually, investors that act on developed markets have access to more information and thus they should act more rationally implying that psychological barriers should not exist in these markets. The objective of this evaluation is to see if in fact developed areas do not have these types of biases while emerging areas do.

We find evidences of psychological barriers in Taiwan and South Korea which are two of the three emerging markets under analysis. Concerning the other four indexes the results are inconclusive, once there are not consistencies across methods.

This dissertation is organized as follows: the next chapter reviews the literature where we explain in detail what are psychological barriers and the reason behind it, we address the efficient market hypothesis problem and finally review existent findings on the matter; the third chapter presents the methodological aspects such as the data used and the methods employed to proof the existence of barriers; the fourth chapter mentions the results obtained and its analysis and conclusion in the fifth.

2. Literature review

Financial markets, nowadays, register a series of behavioural biases that can influence the outcome expected at the end of a trading day. In fact, throughout time many biases have been documented and studied in several markets. Psychological barriers are one of those biases. They were first documented by Donaldson (1990) and De Grauwe and Decupere (1992) from that point on, many were the researchers that contributed to support this theory. So, to start this study it is important to draw some highlights on why psychological barriers may occur in financial markets followed then by some empirical implications that this phenomenon can have and finally, through empirical studies, proof their existence in the various markets, such as equity, commodity, option, foreign exchange and bond markets.

2.1. Cognitive biases

Market indexes represent the aggregate of various stocks that express through time investors' strategies, information and also sentiments. The belief that the market shows, at any point in time, the value of all stocks traded is nowadays under test. More authors state that investors' sentiments and thoughts influence index's value. This is called a behavioural bias. These biases can exist into two forms: cognitive bias or emotional bias.

Cognitive bias is characterized by a constant pattern of deviation from the norm where inferences about other people and situations may be drawn into an illogical background. An emotional bias is represented through a distortion in cognition and decision making due to emotional factors. The so called, psychological barriers that seem to exist in several markets are considered as a cognitive bias and are the reflection of many cognitive biases and also emotional biases.

2.1.1. Psychological barriers

Psychological barriers consist in the difficulty that some investors' have to cross some certain price levels (Aggarwal & Lucey, 2007). There are two different types of barriers depending from where the quote is crossed. If investors' do not break a barrier from above, then, this number is known as a support level; while if an investor do not cross a certain price from below, it is known as a resistance level. For example, imagining a price of 50, if during a certain period of time this price is not crossed to a higher price, than the value 50 is considered a resistance level, however if the trades are done above 50 and this price is not crossed to a lower amount than this is a support level.

2.2. Reasons for psychological barriers

Being psychological barriers a cognitive bias, they occur due to a series of factors that influence investors' decisions. Some of the reasons mentioned below are also cognitive biases and are not only in the background of the existence of these barriers but are also the reason for many other effects found in finance.

2.2.1. Anchoring

"Anchoring is a term used in psychology to describe the common human tendency to rely too heavily (anchor) on one piece of information when making decisions" Westerhoff (2003). This phenomena is found in financial markets with the form of "disposition effect" that is the tendency that people have to sell assets that gained value and keep assets that lost value.

Andersen (2010) used a trading algorithm based on biological motors to detect the presence of anchoring in financial markets. The author found that the decision making process of investors is affected by this phenomenon. Also, Cen *et al.* (2013) stated that market participants when estimating the future profitability of a firm are affected by anchoring. Additionally, Campbell and Sharpe (2009) studied the impact that anchoring has in forecasting. They discovered that investors' monthly economic releases are biases towards the values of previous month's releases.

Westerhoff (2003) researched on foreign exchange markets behaviour and he realized that psychological barriers and anchoring can be related. Traders use the nearest round number as a proxy for fundamental value and psychological barriers function as midpoints between two anchors.

2.2.2. Herding

The herding behaviour is the tendency that individuals' have to mimic the actions (rational or irrational) of a larger group. There are two main reasons to herd: social pressure conformity and the belief that the probability of a larger group being wrong is small. Specifically, the bandwagon effect is off most importance to this study.

The bandwagon effect is a type of herding behaviour. It is the tendency that people have to do something primarily just because other people are doing it, regardless of their opinions and beliefs. This behaviour was mainly observed during the dotcom bubble where dozens of tech start up emerged without having a viable business plan, products or services and even though attracted millions of dollars in investments (Lieberman & Asaba, 2006).

This effect can also be related to psychological barriers in the stock exchange like Dorfleitner and Klein (2009) reported. These authors stated that after breaking a certain barrier, prices quickly moved away from it just because other market participants were already buying the relevant asset.

2.2.3. Odd ending price

In 1997, a sample of 840 advertisements revealed that odd prices outnumbered all other price endings. This data showed that 87% of values were defined as odd prices and that 60% ended with the number 9 and 30% with the number 5. So, 90% of prices ended with 9 or 5; the numbers 0, 5 and 9 appeared 97% and the remaining ones only 3% (Holdershaw & Gendall, 1997).

Odd pricing is when a certain price is established below a round number, for example 9.99$ instead of 10$ (Sonnemans, 2006).

Holdershaw and Gendall (1997) studied the use of odd pricing in the retail sector. The authors started by explaining the reasons for odd pricing. First, the costumers see odd prices being cheaper than they actually are when comparing to the nearest round number. For example, if a certain good costs 4.99$ people tend to see this price closer to 4$ than to 5$. Another possible explanation is that people tend to remember more easily the first digits of a price due to their limited capacity of storing information. And finally, it is believed that individuals are more attracted to circular numbers, such as 9 and also because costumers like to receive change. The researchers concluded that greater than expected demand occurred at odd price points.

Sonnemans (2006) focused his research on price clustering and resistance points in the Dutch stock market around round numbers. The odd pricing hypothesis is used to explain the tendency that people have to lean on round numbers. The author states that in financial markets, a stock price of 30 would be considered much higher than a price of 29.9. This implies that a seller would be satisfied to sell at this price however the buyer would see this as a very high price. In line with this hypothesis, the results showed that after 1 January 1999 the change in round numbers effects was drastic- after changing for euro.

2.2.4. Aspiration levels

Aspiration levels are seen by investors as a target to reach. Particularly, in the stock market, when investors buy an asset they already have in mind the price they are willing to sell in the future. These target prices are normally round numbers because they are rough estimates of the firm's value or future dividends (Sonnemans, 2006).

Besides, these aspirations levels can also be seen as a measure of success or failure considering the outcomes expected. In this perspective an aspiration level is a probability. The importance of this bias is nowadays very high in the decision making process. An aspiration level reinforces loss aversion, can account for both risk averse and risk seeking behaviour and can explain violations of mean reversion approach.

Indeed, Simon (1955) computed a model to explain investors' selling decisions and he considered that, investors would rely more on round numbers because they are not able to maximize their utility due to time, information and calculation limitations. So they would probably define the round number near their estimates as a limit to sell the stock.

2.2.5. Cost efficiency and preference for round numbers

Preece (1981) argued that people tend to simplify the information acquired while mentally processing numbers and with this, individuals are prone to produce a quicker and more cost effective judgement. Blau and Griffith (2016) mention two cost related reasons for investors' preference on round numbers. First, investors' prefer round numbers to mitigate cognitive processing costs and second, they prefer to deal with round numbers as an attempt to minimize negotiation costs.

In fact, according to Mitchell (2001), number preference may also be a reason for clustering and/or psychological barriers. Actually, Sonnemans (2006) in his study of Dutch's stock market states that a possible explanation for clustering is the preference for round numbers. The author says that individuals prefer round numbers and subsequently investors tend to trade around round numbers. This predisposition exists mainly due to convenience. Calculations with this numbers are easier to perform, limits informational load and decreases the probability of costly mistakes.

2.3. Empirical implications

"If markets were always rational and efficient then we would not expect to see any significant psychological barriers in precious metals prices." - Lucey and O'Connor (2016)

2.3.1. Market efficiency theory

Traditional finance has its focus on many topics related with financial markets. One of those areas is the relation established between prices and information. This is known as the market efficiency problem. Many authors dedicated their lives to study this dividing topic of financial markets. Beaver (1981) states that in the security market, this is efficient if prices act if everyone knows the information. Fama (1970) argues that a market that is efficient reflects fully all the information available. According to this author the necessary conditions for market efficiency are: no transaction costs, no informational costs and all participants in the market are aware of the implications of information in prices. There are three forms of market efficiency: strong form- all public and private information is reflected in market prices; semi strong form- prices reflect all publicly available information and weak form- historical data is reflected in today's prices. Donaldson and Kim (1993) considered that the presence of barriers was not a rejection of market efficiency hypothesis. However many other researchers focused now on behavioural finance and with this the hypothesis of efficiency has been under test once behavioural biases can be considered as market anomalies.

The inefficiency of markets can be seen as securities not being correctly priced. The supporters of this hypothesis believe that securities would be under or overvalued allowing investors to gain excess returns. In an efficient market these opportunities would not exist. The reasons for the extant of a market anomaly can be, for example time, costs, psychological reasons and so on. In fact, Agrawal and Tandon (1994) examined five seasonal patterns in stock markets- the weekend, turn-of-the-month, end-of December, monthly and Friday-the-thirteenth effects and found evidences of daily seasonal effects in almost all the countries analysed. Ariel (1987) reported that stocks appear to earn positive average returns around the beginning and during the first half of the calendar months and zero average returns in the second half. Therefore the amount of market anomalies is very wide and the existence of psychological barriers seems to be one of those. Actually, Dorfleitner and Klein (2009) after finding no consistency in the appearance of psychological barriers in stock indexes and discovering that once Cyree *et al.* (1999) studied some indexes they were barriers' free, they concluded that this was a contradiction to market efficiency. Also Bahng (2003), even though discovering just evidences of psychological barriers in the Taiwanese index determined that his findings were against market efficiency hypothesis and investors' rationality.

2.4. Empirical studies

Behavioural finance literature enhances the existence of many behavioural biases present in market indexes. In particular are the psychological barriers that often seemed to appear in market indexes. Along the years, many authors have found evidence that this barriers indeed exist. This phenomenon was found in several stock indexes, such as NASDAQ and DJIA, also in European indexes like FTSE 100, CAC 40 and FAZ General and even in the Asian markets such as the Taiwanese. This bias is not exclusive to the equity market but is also present in the commodity market - gold and oil, option market, in the foreign exchange market and bond market.

2.4.1. Equity market

Starting with the equity market, Donaldson and Kim (1993) were the first to study DJIA and WA indexes, from 1974 until 1990, in order to compare both markets. The time range chosen was limited due to the lack of available data from the WA index. The authors formalized three different tests in order to check the presence of psychological barriers in those indexes. They then found that DJIA index closes frequently around the 100-level and that the conditional returns are negatively correlated with the M-values. Together, these findings expressed that the DJIA rose and fell restrained to resistance and support levels. However, these anomalies did not appear in the WA index. The researchers considered that the results obtained did not reject the market efficiency hypothesis. Besides this they argued that investors are not fully rational. On the other hand, Ley and Varian (1994) examined 41 years of closing values of the DJIA to assess if the presence of psychological barriers had some predictive value in what concerned future stock market returns and their observations and statistical results did not support the hypothesis of psychological barriers in the DJIA. So, they concluded that the closing prices had no influence on predicting future price's behaviour.

Koedijk and Stork (1994) spread their investigation and explored five stock indices across the world focusing on the period between 1980-1992 using daily middle rates. Their results showed that the M-values of four indices were not uniformly distributed. So they decided to divide the sample into sub-samples to evaluate if the results were robust. Three out of five showed to be relatively robust to splitting the sample (FAZ General, FTSE100 and S&P500). This meant that there were evidences of psychological barriers in those markets. Having this in consideration the authors used those discoveries to test returns' predictability. They reached the conclusion that there was no predictability of prices when in the presence of psychological barriers.

At this point, De Ceuster *et al.* (1998) considered Benford's Law (Law of Anomalous Numbers), to test that a stock index do not follow a normal distribution. The researchers criticized the way most studies used the assumption that M-values follow a uniform distribution. Instead of that, the authors applied a test based on cyclical permutations of actual returns, on DJIA, FTSE100 and Nikkei225, and concluded that these indexes do not present evidences of psychological barriers.

Cyree *et al.* (1999) analysed DJIA, S&P500, TSE300, FTSE100, DAX, CAC40, HIS and Nikkei225 from 1968 until 1994 using uniformity tests and introducing a new approach of the conditional returns to test psychological barriers. This method applies a GARCH (generalized autoregressive conditional heteroskedastic) in mean model with indicator variables in the mean and variance in order to identify changes in the conditional returns immediately before and after crossing a barrier. Their study showed that the DJIA and Nikkei225 were the only indexes that present signs of psychological barriers, when looking for both upward and downward movements. This phenomenon may have happened, according with the authors, because these are indexes that have much attention from the media/investors and also because DJIA it is price weighted rather than value weighted. When looking to a downward movement, CAC40 was the only index that showed an increase in the variances in the post crossing period.

The Asian markets were finally studied by Bahng (2003). This author selected stock prices from seven Asian emerging markets- South Korea, Taiwan, Hong Kong, Singapore, Thailand, Malaysia and Indonesia from 1990-1999. The methodology chosen was a regression test, barrier proximity, supported by a simulation test to confirm the robustness of the results (bootstrapping technique), and finally a hump shape test. The conclusion of this study was that the Taiwanese, Indonesian and Hong Kong indexes possessed price barrier effects. The presence of this effect was considered by the author as market inefficiency since he interprets this as prices not reflecting the true values around these reference levels. Besides this, the researcher states that these findings were representative of a market anomaly once the paper was developed considering emotional and irrational behaviour of investors.

Dorfleitner and Klein (2009) studied DAX30, CAC40, FTSE100 and DJ EURO STOXX50 from 1996 until 2003 and also some individual stocks from DAX30. The authors examined psychological barriers around 100-level and 1000-level. They concluded that there were no consistent barriers in European stock indices or individual stocks. These findings, according to the authors, constitute a contradiction to market efficiency and investors' rationality. Besides this, they discovered that after the findings of Cyree *et al.* (1999) in some markets the barriers previously found disappeared. The researchers believe that these findings can be seem as market anomalies once it is an argument against market efficiency hypothesis and rational investors.

Finally, in the NASDAQ Composite Index, Woodhouse *et al.* (2016) evaluated daily closing values from 1990 until 2012 and revealed that the price index indeed showed signs of psychological barriers. To analyse this hypothesis the authors exploited the test of conditional returns and barrier tests. They believe that this discovery indicates a behavioural underpinning however, they consider that these barriers are not enough to overrule efficient market hypothesis since there were not sufficient arbitrage opportunities to investors.

2.4.2. Commodity market

The commodity market was also studied for the extant of these resistance and support levels. Aggarwal and Lucey (2007) focused on the existence of psychological barriers in gold prices. The commodity indexes studied for daily and intra daily prices were London AM Fix, COMEX and UBS London for different time ranges. The methods that were used took in consideration the uniformity of the distribution, the shape of the distribution and the returns of gold prices. Psychological barriers were found at the 100-level for daily prices however, for high frequency gold prices the evidence was weaker but the authors stated that this occurred mainly due to the particularities of the period in analysis. Concerning the examination of returns, the variance had suffered strong changes around and when crossing psychological price barriers in gold markets. Conditional means also presented evidences of changes around psychological barriers. More recently, Lucey and O'Connor (2016) studied on the extant of psychological barriers in gold and silver prices, at numbers ending with 0 and 00. The period analysed (1975-2015) appeared to be the ideal because, the price volatility recorded for these commodities, in the late years, was especially high. So, intraday day gold prices from London AM and PM fix and daily silver prices from the London fix were collected. The authors performed three different types of examinations (uniformity tests, barrier tests and conditional returns). They then concluded for the presence of psychological barriers at 0 and 00 endings in gold prices while for silver prices the results were the opposite, meaning no psychological barriers.

Dowling *et al.* (2016) searched on the hypothesis of psychological barriers in oil futures. The study was conducted on Brent and WTI contracts using barrier tests and conditional effects from 1990 until 2012. The results encountered around 10-digits show that psychological barriers only influence prices in the pre-credit crisis of 1990-2006 and after that; the effect was dissipated during oil price bust. Brent presented stronger evidences of psychological barriers than WTI and the authors justified this with the apparent rise of Brent importance in the oil markets. Besides this the authors studied the reaction time of the market when a barrier was crossed. They found that normally, the market takes 5 trading days to react to this event.

2.4.3. Option market

The option market was studied by Jang *et al.* (2015) using data of S&P500 and VIX indexes from 8-7-2011 until 19-1-2012. These authors’ objective was to find evidences of psychological barriers in those markets and at the same time analyse its influence at index’s rate of return and volatility. Subsequently they suggested a threshold model, incorporating the impact of these barriers, and they assessed its performance on option pricing and hedging comparing to Black and Scholes model and CEV models (constant elasticity of variance). The main goal of this model was to predict pricing formulas of European options. The methodology employed was a Kolmogrov- Smirnov test and barrier tests. The impact on returns and volatility was studied with a GARCH model. Their conclusions suggest that S&P500 presents psychological barriers at each 100-level. Regarding the conditional effects, they found that conditional mean return changes once it passes the barrier both from above and below whereas conditional variance only changes during downturns.

2.4.4. Foreign exchange market

In the foreign exchange market, Westerhoff (2003) found that the value of a currency is anchored to the nearest round numbers. The author argues that this anchoring phenomenon leads to possible misalignments of exchange rates since they fluctuate between upper and down perceived fundamentals. These limits can be understood as resistance and support levels, the two types of psychological barriers existent. The researchers say that central authorities can solve these distortions if exchange rates were pushed to less biased anchors, however to do that they need to break the existent psychological barriers.

2.4.5. Bond market

Burke (2001) conducted the first study of psychological barriers on bonds. Using a uniformity test and barrier tests on US benchmark bonds' yields for 2, 5, 10 and 30 years from 1983 to 2000, the author found deviations from uniformity. However the same did not happen for GARCH (generalized autoregressive conditional heteroskedastic) framework.

3. Data and methods

In this chapter we will present the methodological aspects of our study such as data, series' construction and tests used.

3.1. Data

The main objective of this study is to check if the most important Asian markets presented, in the past, signs of psychological barriers, thus, we selected six areas from that specific geography. The selection was made according to the MSCI ACWI Index weight attributed to Asian markets for developed and emerging markets. As of January 2017, the markets with highest weight on the mentioned index, in the category of emerging markets in Eastern and Oriental Asia, were China, South Korea and Taiwan. On the other hand, the developed markets presented were Hong Kong, Japan and Singapore. Hence, and because the aim is to examine only the equity market, the following indexes will be under analysis: Shanghai SE Composite Index (China), KOSPI (South Korea), Taiwan SE Weighted DS (Taiwan), Hang Seng (Hong Kong), Nikkei 225 (Japan) and Straits Times Index (Singapore). The time range under analysis match the start of each index, because we want to do a more extensive and profound investigation. The summary of the information above mentioned can be seen in Table 1. The data was collected from Thomson Reuters Datastream.

Table 1 - Data used in the study

Area	Index	Start date	End date
China	Shanghai SE Composite	January 2nd, 1991	
South Korea	KOSPI	December 31st, 1974	
Taiwan	Taiwan SE Weighted DS	July 3rd, 1989	December 31st, 2016
Hong Kong	Hang Seng	July 31st, 1964	
Japan	Nikkei 225	April 3rd, 1950	
Singapore	Straits Times Index	August 31st, 1999	

From now on, in this study, we will mention the name of the area under study instead of the index's name to make it easy for the reader to identify results and tables. Table 2 presents a summary of the statistics of the used data.

Table 2 – Summary statistics of the used data

Series	N	Return Series				Level series	
		Mean	Std. Dev.	Skew.	Kurt.	Max.	Min.
China	6783	0.00046	0.022	5.41	161.64	6092.05	105.77
South Korea	10959	0.00031	0.014	-0.31	11.364	2228.96	65.35
Taiwan	7175	-3.26×10^{-5}	0.016	-0.11	7.4451	145.04	30.73
Hong Kong	13676	-0.00039	0.017	1.09	37.273	31638.22	58.61
Japan	17415	0.0003	0.011	-0.4	13.551	38915.87	85.25
Singapore	4524	6.11×10^{-5}	0.011	-0.25	8.4553	3831.31	1170.85

3.2. Empirical study methodology

The existence of psychological barriers can be examined in many different ways; however, the following approaches are the most important and commonly used by researchers.

1. Uniformity tests
2. Barrier tests
3. Conditional effects tests

The uniformity tests or tests of the distribution of the digits are based on the assumption that the M- values follow a uniform distribution in the absence of psychological barriers. This type of assessments can be done with different methods however; we will use a Kolmogorov- Smirnov Z- test.

Regarding, barrier tests or tests of the frequency of the digits around presupposed barriers, there are two possibilities that can be applied to study this matter. The barrier proximity test, first introduced by Donaldson and Kim (1993), computes a regression where the frequency with which an index closes in the last digits, minus one percent, depends on a dummy variable that assumes value 0 when out of a certain interval of values. And the hump shape test, developed by Bertola and Caballero (1992), where the same frequency mentioned above is regressed with the M-values and its square.

The tests of the behaviour of returns around barriers, Cyree *et al.* (1999) designed a GARCH (generalized autoregressive conditional heteroskedastic) model with additional indicator variables to test the changes in the conditional means and variances of daily index returns around presupposed barriers. This method also notes if a barrier is being approached from above or below.

3.2.1. M- values

M-values are defined as the last two digits in the integer portion of a certain price and will range between 00 and 99 at the 100-level. This concept was first introduced by Donaldson and Kim (1993) that determined the existence of possible psychological barriers at the levels …, 300, 400, …, 3400, 3500, …

$$k * 100, \qquad k = 1, 2, \ldots$$

However, De Ceuster *et al.* (1998) found two problems with this approach. First, the series was not multiplicatively regenerative, meaning that 3400 would be considered a barrier while 340 was not. And second, successive barriers should not be too close to each other, but in this case the relative gap between barriers would go to zero as the level of an index increases. Therefore, these authors claimed that barriers should be considered at …,10, 20, …,100, 200, …, 1000, 2000, …

$$k * 10^l, \qquad k = 1, 2, \ldots, 9\, ; l = \cdots, -1, 0, 1, \ldots$$

And alternatively, at levels …, 10, 11, …, 100, 110, …, 1000, 1100, …

$$k * 10^l, \qquad k = 10, 11, \ldots, 99\, ; l = \cdots, -1, 0, 1, \ldots$$

Thus, the M-values that transmit the information on the relative closeness to a barrier are the next step to study.

a) M1 is computed as

$$M1 = (P_t * 100)\, mod\, 100 \qquad (1)$$

P_t is the quote, $(P_t * 100)$ is the integer part of $P_t * 100$ and $mod\ 100$ is the reduction modulo of 100. For example, if the quote is 1579.35 or 687.23 then the M1's are 35 and 23, respectively.

b) M10 is computed as

$$M10 = (P_t * 10)\, mod\, 100 \qquad (2)$$

P_t is the quote, $(P_t * 10)$ is the integer part of $P_t * 10$ and $mod\ 100$ is the reduction modulo of 100. For example, if the quote is 1579.35 or 687.23 then the M10's are 93 and 72, respectively.

c) M100 is computed as

$$M100 = (P_t)\ mod\ 100 \qquad (3)$$

P_t is the quote, (P_t) is the integer part of P_t and $mod\ 100$ is the reduction modulo of 100. For example, if the quote is 1579.35 and 687.23 then the M100's are 79 and 87, respectively.

d) M1000

$$M1000 = (P_t)\ mod\ 1000 \qquad (4)$$

P_t is the quote, (P_t) is the integer part of P_t and $mod\ 1000$ is the reduction modulo of 1000. For example, if the quote is 1579.35 and 687.23 then the M1000's are 579 and 687, respectively.

3.2.2. Uniformity

This particular test examines the possibility of M-values following a uniform distribution, in each of its levels. So, to analyse this supposition we choose to run a Kolmogorov-Smirnov Z test that will compare our data distribution with a uniform one. Therefore, the null tests the hypothesis of uniform distribution against a second hypothesis of not following a uniform distribution. It is expected that the rejection of the null evidences the presence of psychological barriers.

However, as Ley and Varian (1994) stated, this rejection is not sufficient to attest the existence of such barriers. Besides this, De Ceuster *et al.* (1998) claimed that in series that grow without a limit, widen the intervals between barriers, the occurrence is no longer uniform. And also Dorfleitner and Klein (2009) found that this may not be a good way to test the extant of barriers since the M-values could show a certain degree of autocorrelation.

3.2.3. Barrier tests

Barrier tests were introduced by Donaldson and Kim (1993) to examine the DJIA index. These tests serve to analyse the possible systematic deviation from a uniform distribution that M-values can suffer when around psychological barriers. These methods have been applied by many authors in their researches such as commodities or bond yields. There are two different types of tests that can be executed: the barrier proximity test and the barrier hump test.

3.2.3.1. Barrier proximity test

This first test examines the tails of the distribution around presupposed barriers. The equation that we are going to apply is as follows:

$$f(M) = \alpha + \beta D_{ij} + U_M; M = 00, 01, \ldots, 99 \qquad (5)$$

Where $f(M)$ is defined as the frequency with which an index closes with its last two digits in cell M, minus 1 percent. And a dummy variable, D_{ij}, that takes the value 1 when the price of stock is at the supposed barrier and 0 elsewhere. The results of this test are based in the coefficients of β. Thus, if they end up to be 0, we conclude that there are no barriers whereas; if we found a negative and significant coefficient, i.e., a low frequency of the M-values, psychological barriers are present in the index.

The dummies studied for the 1-level, 10-level and 100-level are:

$D_{98\text{-}02}$ = 1 if M ≥ 98 or M ≤ 02, = 0 otherwise

$D_{95\text{-}05}$ = 1 if M ≥ 95 or M ≤ 05, = 0 otherwise

$D_{90\text{-}09}$ = 1 if M ≥ 90 or M ≤ 10, = 0 otherwise

In the case of 1000-level the M-values will range between 000 and 999 being the dummies as follows:

$D_{980\text{-}20}$ = 1 if M ≥ 980 or M ≤ 20, = 0 otherwise

$D_{950\text{-}50}$ = 1 if M ≥ 950 or M ≤ 50, = 0 otherwise

$D_{900\text{-}90}$ = 1 if M ≥ 900 or M ≤ 100, = 0 otherwise

This test, in particular, depends on the length of the dummy variable which can influence the outcome of this analysis as showed in previous papers. Besides this, it’s normal to find in stock indices a low R-square, indicating that the dummy variable is not the best option to assess if there are barriers.

3.2.3.2. Barrier hump test

The second test assesses the entire shape of the distribution around presupposed barriers. Bertola and Caballero (1992) regressed the following equation:

$$f(M) = \alpha + \beta M + \delta M^2 + U_M; M = 00, 01, \ldots, 99 \qquad (6)$$

Where $f(M)$ is defined as the frequency with which an index closes with its last two digits in cell M, minus 1 percent. And the independent variables are the M-values and its square. This intends to test if the distribution follows some kind of particular shape. So, the null hypothesis is when the distribution of the M-values appears to be uniform, indicating an absence of barriers. In the other hand, if the distribution has some particular shape, psychological barriers are present in the index. In the case of the authors referred earlier, a hump-shape distribution is an alternative to test this hypothesis. It is expected that, under the null δ should be zero while, under the alternative δ would be negative. The regression exposed refers to the study of the 1s, 10s and 100s levels. When applying this to the 1000-level the M-values will vary between 000 and 999.

3.2.4. Conditional effects tests

Cyree *et al.* (1999) and Donaldson and Kim (1993) developed a new approach to analyse if major indexes presented evidences of psychological barriers. Their experiment looks at possible changes in the mean and variance of conditional returns around potential barriers. Moreover, this method examines if a barrier is being approached from above or below.

Using a GARCH (generalized autoregressive conditional heteroskedastic) method we will be estimating a mean equation with indicator variables as well as a variance equation to assess potential changes in the vicissitudes of psychological barriers. First, using an ordinary least squares (OLS) model we will regress the following equation:

$$R_t = \beta_1 + \beta_2 UB_t + \beta_3 UA_t + \beta_4 DB_t + \beta_5 DA_t + \varepsilon_t \qquad (7)$$

However, as stated by Cyree *et al.* (1999), the potential conclusions taken out of the previous estimation can be dubious because distributional shifts implied by psychological barriers invalidate basic assumptions of OLS. These results will be displayed just as a reference point. Therefore, and considering the invalidity of OLS' estimation, the next step is then regress the same mean equation using a GARCH (generalized autoregressive conditional heteroskedastic) approach, which implies that: $\varepsilon_t \sim N(0, V_t)$

Afterwards we will use once again a GARCH (generalized autoregressive conditional heteroskedastic) model to estimate the following variance regression where we ad a moving average parameter and a GARCH parameter.

$$V_t = \alpha_1 + \alpha_2 UB_t + \alpha_3 UA_t + \alpha_4 DB_t + \alpha_5 DA_t + \alpha_6 V_{t-1} + \alpha_7 \varepsilon_{t-1}^2 + \eta_t \qquad (8)$$

The indicator variables are UB for the period before an upward movement, UA for the period after an upward movement, DB for the period before a downward movement and DA for the period after a downward movement through a barrier. A period will be defined as 10 day duration. These dummy variables will take the value 1 for the days noted and 0 otherwise. In the absence of barriers it is expected that the coefficients of the indicator variables take values different from zero in both situations (mean and variance).

The hypotheses under test are:

H_1: There is no difference in the conditional mean return before and after an upward crossing of a barrier.

H_2: There is no difference in the conditional mean return before and after a downward crossing of a barrier.

H_3: There is no difference in the conditional variance before and after an upward crossing of a barrier.

H_4: There is no difference in the conditional variance before and after a downward crossing of a barrier.

4. Empirical study

In this section we present the results of our study as well as an analysis to each test's results.

4.1. Uniformity tests

Table 3 shows the results of uniformity tests using a Kolmogorov- Smirnov Z test that studies the distribution of the trailing digits in six Asian markets. Overall the indexes under study show signs of psychological barriers, meaning that the M-values did not follow a uniform distribution. There are four indexes that present robust evidence of rejecting the null hypothesis of uniformity for all M-values analysed at all significance levels. The presence of barriers is also found in the Chinese market for all levels except for the second lowest level. Singapore only displays evidences of rejecting uniformity for two levels of M-values (M100 and M1000).

4.2. Barrier tests

4.2.1. Barrier proximity test

The following Tables 4-7 show the results for the barrier proximity test conditional to a certain barrier, mentioned previous in Section 3.2.3.1. It is expected that a negative and significant β, i.e., a low frequency of M-values, would demonstrate the presence of psychological barriers. Considering a barrier in the exact zero modulo point (see Table 4), there are no index that present evidences of rejecting the no barrier hypothesis. If we assume a barrier to be in the interval 98-02 and 980-20, we see in Table 5 that three indexes seem to present negative and significant β coefficients. In the case of Singapore the presence of barriers is seen at the 100-level for a 10 percent significant level and for Hong Kong and Japan at 1000-level we reject the no barrier hypothesis for 1 percent significance level. Considering the 95-05 and 950-50 barrier restrictions (see Table 6) it is clear that psychological barriers are present in all M levels. China at 10 percent significance level has barriers at 1-level; South Korea at 5 percent significance level presents barriers for 10-level; both Taiwan at 1 percent significance level as Singapore at 5 percent significance level present psychological barriers at the 100-level and finally Hong Kong and Japan reject the no barrier hypothesis at 1 percent significance level for 1000-level. Regarding the 90-10 and 900-100 boundaries (see Table 7) all M levels present signs of psychological barriers. Actually, South Korea shows psychological barriers at 10-level for 10 percent significance level. Taiwan at 1 percent significance level and Singapore at 10 percent significance level present evidence of barriers for 100-level. Finally the no barrier hypothesis at 1000-level is again rejected for the Japanese index at 1 percent significance level.

4.2.2. Barrier hump test

The barrier hump test is used to check the entire shape of the M-values' distribution. Under the assumption of psychological barriers it is expected a negative and significant δ, meaning that the distribution is not uniform but rather hump shaped. The evidences appearing in Table 8 confirm the findings of the proximity tests performed previously. At 1 percent significant level South Korea rejects the null hypothesis of uniformity for 10-level, Taiwan at 1 percent significant level seems to exhibit a hump shape distribution for 100-level and finally Japan at 1 percent significant level rejects the no barrier hypothesis, once again, for 1000-level.

Overall, it is possible to say that, so far, all Asian indexes under analysis present signs of possessing psychological barriers. We find some consistency in South Korea for 10-level, Taiwan for 100-level and Japan for 1000-level. Regarding the other indexes, there is no clear pattern across the results of the tests performed until this point.

Table 3 – Uniformity test results

Series	Statistic	M1	M10	M100	M1000
China	Kolmogorov (D) – Stat. value (adjusted)	1.235	1.196	1.817	6.861
	P-value	0.094*	0.114	0.002***	0.000***
South Korea	Kolmogorov (D) – Stat. value (adjusted)	1.466	2.074	9.788	19.219
	P-value	0.027**	0.000***	0.000***	0.000***
Taiwan	Kolmogorov (D) – Stat. value (adjusted)	1.675	2.148	25.034	-
	P-value	0.007***	0.000***	0.000***	-
Hong Kong	Kolmogorov (D) – Stat. value (adjusted)	3.524	3.064	4.210	10.434
	P-value	0.000***	0.000***	0.000***	0.000***
Japan	Kolmogorov (D) – Stat. value (adjusted)	1.869	2.136	1.861	10.360
	P-value	0.001***	0.000***	0.002***	0.000***
Singapore	Kolmogorov (D) – Stat. value (adjusted)	1.059	1.162	1.386	4.891
	P-value	0.211	0.134	0.042**	0.000***

Each test was performed for the daily closing prices of each index. This table shows the results of a Kolmogorov- Smirnov Z test for uniformity of the distribution. The D line presents the statistic results and the P-value shows the marginal significance of these statistics. H_0: Uniform distribution, H_1: Non uniform distribution.
Significant at 1 percent level ***
Significant at 5 percent level **
Significant at 10 percent level *

Table 4 – Barrier proximity test results for the strict barrier

Series	98-02 dummy									980-20 dummy		
	M1			M10			M100			M1000		
	β	P-value	R^2	β	P-value	R^2	β	P-value	R^2	β	P-value	R^2
China	-0.026	0.859	0.000	-0.116	0.448	0.005	-0.057	0.707	0.001	-0.011	0.824	0.000
South Korea	0.040	0.715	0.001	0.040	0.733	0.001	0.059	0.813	0.000	0.073	0.490	0.000
Taiwan	0.355	0.014**	0.059	-0.010	0.950	0.000	-0.559	0.538	0.003	-	-	-
Hong Kong	1.70	0.000***	0.604	0.570	0.000***	0.118	0.245	0.250	0.013	-0.026	0.697	0.000
Japan	0.051	0.505	0.004	0.091	0.250	0.013	0.057	0.477	0.005	-0.025	0.479	0.000
Singapore	-0.228	0.152	0.020	0.136	0.338	0.009	-0.183	0.215	0.015	0.054	0.306	0.001

The table shows the results of the regression $f(M) = \alpha + \beta D_{ij} + U_M$ where the dependent variable is the frequency of appearance of the M-values minus 1 percent and D_{ij} represents a dummy variable that takes the value 1 at a supposed barrier and 0 otherwise. The strict barrier takes the value 1 when the M-value is in 00 or 000. The β column characterizes the coefficient of the regression under analysis; the P-value shows the marginal significance of these statistics and R^2 represents the determination coefficient.

Significant at 1 percent level ***

Significant at 5 percent level **

Significant at 10 percent level *

Table 5 – Barrier proximity test results for the 98-02 and 980-20 dummies

Series	98-02 dummy									980-20 dummy		
	M1			M10			M100			M1000		
	β	P-value	R^2	β	P-value	R^2	β	P-value	R^2	β	P-value	R^2
China	-0.102	0.139	0.022	0.030	0.639	0.002	0.039	0.564	0.003	-0.009	0.237	0.001
South Korea	-0.044	0.385	0.007	-0.030	0.573	0.003	0.000	0.999	0.000	0.025	0.127	0.002
Taiwan	0.121	0.070*	0.033	0.027	0.723	0.001	-0.65	0.115	0.025	-	-	-
Hong Kong	0.338	0.000***	0.115	0.172	0.022**	0.052	0.266	0.005***	0.076	-0.024	0.027**	0.004
Japan	0.06	0.05**	0.03	0.049	0.171	0.018	0.014	0.686	0.001	-0.021	0.000***	0.013
Singapore	-0.010	0.889	0.000	0.008	0.905	0.000	-0.121	0.071*	0.032	0.020	0.016**	0.005

The table shows the results of the regression $f(M) = \alpha + \beta D_{ij} + U_M$ where the dependent variable is the frequency of appearance of the M-values minus 1 percent and D_{ij} represents a dummy variable that takes the value 1 at a supposed barrier and 0 otherwise. The 98-02 barrier takes the value 1 in 00, 01, 02, 98, 99 values. For the M1000 level the same applies but between 980-20. The β column characterizes the coefficient of the regression under analysis; the P-value shows the marginal significance of these statistics and R^2 represents the determination coefficient.

Significant at 1 percent level ***

Significant at 5 percent level **

Significant at 10 percent level *

Table 6 - Barrier proximity test results for the 95-05 and 950-50 dummies

Series	95-05 dummy									950-50 dummy		
	M1			M10			M100			M1000		
	β	P-value	R^2	β	P-value	R^2	β	P-value	R^2	β	P-value	R^2
China	-0.082	0.086*	0.029	0.046	0.304	0.010	0.034	0.475	0.005	-0.006	0.269	0.001****
South Korea	0.020	0.553	0.003	-0.083	0.026**	0.049	0.150	0.057*	0.036	0.014	0.183	0.001
Taiwan	0.048	0.304	0.010	0.069	0.192	0.017	-0.747	0.008***	0.068	-	-	-
Hong Kong	0.131	0.060*	0.035	0.95	0.071*	0.032	0.081	0.227	0.014	-0.027	0.000***	0.014
Japan	0.057	0.017**	0.056	0.035	0.163	0.019	-0.009	0.702	0.001	-0.020	0.000***	0.029
Singapore	-0.012	0.803	0.000	0.021	0.668	0.001	-0.091	0.050**	0.038	0.009	0.107	0.002

The table shows the results of the regression $f(M) = \alpha + \beta D_{ij} + U_M$ where the dependent variable is the frequency of appearance of the M-values minus 1 percent and D_{ij}represents a dummy variable that takes the value 1 at a supposed barrier and 0 otherwise. The 95-05 barrier takes the value 1 in 00, 01, 02, 03, 04, 05, 95, 96, 97, 98, 99 values. For the M1000 level the same applies but between 950-50. The β column characterizes the coefficient of the regression under analysis; the P-value shows the marginal significance of these statistics and R^2 represents the determination coefficient.
Significant at 1 percent level ***
Significant at 5 percent level **
Significant at 10 percent level *

Table 7 - Barrier proximity test results for the 90-10 and 900-100 dummies

Series	90-10 dummy									900-100 dummy		
	M1			M10			M100			M1000		
	β	P-value	R^2	β	P-value	R^2	β	P-value	R^2	β	P-value	R^2
China	-0.033	0.379	0.007	0.020	0.561	0.003	0.036	0.335	0.009	-0.00	0.112	0.002
South Korea	-0.011	0.683	0.001	-0.052	0.075*	0.031	0.040	0.521	0.004	0.026	0.001***	0.009
Taiwan	0.023	0.521	0.004	0.062	0.131	0.023	-0.885	0.000***	0.156	-	-	-
Hong Kong	0.062	0.258	0.01	0.021	0.600	0.002	0.035	0.509	0.004	0.016	0.003***	0.008
Japan	0.038	0.043**	0.041	0.022	0.256	0.013	0.013	0.484	0.005	-0.024	0.000***	0.073
Singapore	0.025	0.528	0.004	0.036	0.346	0.009	-0.060	0.100*	0.027	0.010	0.011**	0.006

The table shows the results of the regression $f(M) = \alpha + \beta D_{ij} + U_M$ where the dependent variable is the frequency of appearance of the M-values minus 1 percent and D_{ij}represents a dummy variable that takes the value 1 at a supposed barrier and 0 otherwise. The 90-10 barrier takes the value 1 in 00, 01, 02, 03, 04, 05, 06, 07, 08, 09,10, 90, 91, 92, 93, 94,95, 96, 97, 98, 99 values. For the M1000 level the same applies but between 900-90. The β column characterizes the coefficient of the regression under analysis; the P-value shows the marginal significance of these statistics and R^2 represents the determination coefficient.
Significant at 1 percent level ***
Significant at 5 percent level **
Significant at 10 percent level *

Table 8 - Barrier hump shape test results

Series	M1			M10			M100			M1000		
	δ	P-value	R^2	δ	P-value	R^2	δ	P-value	R^2	δ	P-value	R^2
China	-2.98×10^{-5}	0.143	0.024	2.65×10^{-6}	0.890	0.004	1.58×10^{-5}	0.435	0.009	3.76×10^{-8}	0.072*	0.105
South Korea	-1.78×10^{-6}	0.905	0.002	-4.56×10^{-5}	0.003***	0.116	6.30×10^{-5}	0.023**	0.335	4.96×10^{-7}	0.000***	0.120
Taiwan	1.84×10^{-5}	0.346	0.035	4.14×10^{-5}	0.063*	0.042	-0.000683	0.000***	0.471	-	-	-
Hong Kong	5.73×10^{-5}	0.048**	0.066	5.13×10^{-5}	0.019**	0.070	6.93×10^{-5}	0.014**	0.067	3.61×10^{-6}	0.204	0.062
Japan	2.39×10^{-5}	0.018**	0.057	7.66×10^{-6}	0.464	0.058	-8.30×10^{-7}	0.937	0.031	-1.70×10^{-7}	0.000***	0.183
Singapore	-5.60×10^{-6}	0.794	0.003	3.38×10^{-6}	0.871	0.000	-3.16×10^{-5}	0.103	0.069	1.60×10^{-7}	0.000***	0.060

The table shows the results of the regression $f(M) = \alpha + \beta M + \delta M^2 + U_M$ where the dependent variable is the frequency of appearance of the M-values minus 1 percent and M represents the M-values and its square. These range between 00 and 99 for M1, M10 and M100 and between 000-999 for M1000. The δ column characterizes the coefficient of the regression under analysis; the P-value shows the marginal significance of these statistics and R^2 represents the determination coefficient. H_0: Uniform distribution, H_1: Hump shape distribution.
Significant at 1 percent level ***
Significant at 5 percent level **
Significant at 10 percent level *

4.3. Conditional effects tests

The conditional effects test serves to assess the presence of barriers as well as to check if a potential barrier is being crossed from above or below. Therefore, the dynamics of the returns in the presence of psychological barriers need to be analysed, both for mean and variance. From Table 9 we can see that the coefficients of UA appear to be greater in magnitude than UB in four of the six indexes tested, whereas the coefficients of DA are greater in magnitude than DB, for three of the equity Asian markets. However OLS estimation is invalid in the presence of psychological barriers as mentioned in Section 3.2.4.

Table 10 contains the results of the GARCH model with indicator variables for before and after both upward and downward movements through potential barriers. Four out of six indexes have significantly higher returns after crossing a barrier as part of an upward movement than in the pre-crossing period. While after a downward movement four of the indexes perform worst in terms of return. In line with the findings of Cyree *et al.* (1999), four out of six indexes show negative coefficients both for DB and DA with greater magnitude appearing in the post-crossing period for three of them.

The results displayed in Table 11 show the conditional variance effects. The constant is positive and significant for all indexes. The coefficients of the lagged squared residuals are positive and significant at a 1 percent significant level meaning that conditional variances increase with higher residuals from the period before. All GARCH coefficients are positive and statistically relevant at 1 percent significance, which indicates substantial GARCH effects. For South Korea this term is much closer to the unit that may point out to a higher degree of volatility. The coefficient of the lagged volatility in Hong Kong and Japan is lower than the one found in the study by *Cyree et al.* (1999) which can be explained by the different sample sizes. Variance suffers some significant changes after a barrier is crossed from above and/or below. However, in the case of Singapore there is no significant variation in the pre and post period after breaking through a barrier and so we will leave it out of the analysis from now on. The coefficients of UB and UA are all significant at a five percent significant level, except the Chinese UA coefficient. According to our results, after an upward movement, volatility tends to increase in the case of Taiwan and Japan. This contradicts Cyree *et al.* (1999) findings once their conclusions state that before upward crossings, markets are more volatile and “calmer” after the breach. We can find this tendency in the case of China and Hong Kong which show greater UA coefficients. Concerning the downward movement the conclusions are more heterogeneous and there are less significant coefficients. The post crossing period tends to present higher levels of volatility than in the pre crossing period in the case of Hong Kong and Japan. In both cases the coefficients are negative and significant at five percent significant level. South Korea and Taiwan at one percent significant level present positive and negative DB coefficients, respectively.

Table 9 - Conditional effects test results OLS (return equation)

Series	c	UB	UA	DB	DA
China	0.051	0.225	0.244	-0.135	-0.299
	(0.087)*	(0.149)	(0.117)	(0.309)	(0.024)**
South Korea	0.035	0.061	0.149	-0.124	-0.146
	(0.018)**	(0.407)	(0.041)**	(0.068)*	(0.033)**
Taiwan	-0.0007	0.035	0.579	0.020	-0.694
	(0.969)	(0.849)	(0.002)***	(0.912)	(0.000)***
Hong Kong	-0.041	0.542	-0.051	0.128	0.172
	(0.005)***	(0.049)**	(0.851)	(0.633)	(0.523)
Japan	0.030	0.122	0.014	0.051	-0.319
	(0.000)***	(0.430)	(0.926)	(0.740)	(0.041)**
Singapore	0.008	-0.005	0.280	-0.161	-0.123
	(0.643)	(0.950)	(0.002)***	(0.058)*	(0.147)

The table shows the results of an OLS estimation of the regression $R_t = \beta_1 + \beta_2 UB_t + \beta_3 UA_t + \beta_4 DB_t + \beta_5 DA_t + \varepsilon_t; \varepsilon_t \sim N(0, V_t)$.The dependent variable is the daily return of each index and the indicator variables UB for the period before an upward movement, UA for the period after an upward movement, DB for the period before a downward movement and DA for the period after a downward movement through a barrier. A period is defined as 10 day duration. The first line corresponds to the coefficients of the dummy variables under analysis and the P-value under parenthesis shows the marginal significance of these statistics. Under study are the 10-barrier for South Korea, 100-barrier for China, Taiwan and Singapore and the 1000-barrier for Hong Kong and Japan.
Significant at 1 percent level ***
Significant at 5 percent level **
Significant at 10 percent level *

Table 10 - Conditional effects test results GARCH (return equation)

Series	c	UB	UA	DB	DA
China	0.037	0.202	0.231	-0.097	-0.155
	(0.589)	(0.372)	(0.392)	(0.441)	(0.298)
South Korea	0.038	-0.043	0.265	-0.122	-0.250
	(0.013)**	(0.497)	(0.000)***	(0.064)**	(0.000)***
Taiwan	-0.0001	-0.247	0.341	-0.090	-0.676
	(0.995)	(0.003)***	(0.003)***	(0.401)	(0.000)***
Hong Kong	-0.072	-0.205	-0.010	0.038	0.102
	(0.035)**	(0.011)**	(0.943)	(0.733)	(0.572)
Japan	0.032	0.087	0.034	0.026	-0.200
	(0.126)	(0.779)	(0.872)	(0.923)	(0.191)
Singapore	0.011	-0.005	0.262	-0.148	-0.126
	(0.776)	(0.666)	(0.013)**	(0.130)	(0.198)

The table shows the results of a GARCH estimation of the regression $R_t = \beta_1 + \beta_2 UB_t + \beta_3 UA_t + \beta_4 DB_t + \beta_5 DA_t + \varepsilon_t;\ \varepsilon_t \sim N(0, V_t); V_t = \alpha_1 + \alpha_2 UB_t + \alpha_3 UA_t + \alpha_4 DB_t + \alpha_5 DA_t + \alpha_6 V_{t-1} + \alpha_7 \varepsilon_{t-1}^2 + \eta_t$. The dependent variable is the daily return of each index and the indicator variables UB for the period before an upward movement, UA for the period after an upward movement, DB for the period before a downward movement and DA for the period after a downward movement through a barrier. V_{t-1} refers to the moving average parameter and ε_{t-1}^2stands for the GARCH parameter. A period is defined as 10 day duration. The first line corresponds to the coefficients of the dummy variables under analysis and the P-value under parenthesis shows the marginal significance of these statistics. Under study are the 10-barrier for South Korea, the 100-barrier for China, Taiwan and Singapore and the 1000-barrier for Hong Kong and Japan.
Significant at 1 percent level ***
Significant at 5 percent level **
Significant at 10 percent level *

Table 11 - Conditional effects test results GARCH (variance equation)

Series	c	ε_{t-1}^2	V_{t-1}	UB	UA	DB	DA
China	4.145	0.130	0.568	-1.161	-1.281	-0.097	-0.155
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.001)***	(0.441)	(0.298)
South Korea	0.008	0.046	0.948	-0.019	0.007	0.090	-0.005
	(0.000)***	(0.673)	(0.000)***	(0.000)***	(0.125)	(0.000)***	(0.159)
Taiwan	1.720	0.140	0.364	-0.747	-0.607	-0.582	0.107
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.115)
Hong Kong	2.542	0.114	0.531	-1.539	-2.235	-2.325	-0.455
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.013)**
Japan	1.201	0.084	0.111	-0.373	-0.087	-0.461	-0.809
	(0.000)***	(0.000)***	(0.000)***	(0.016)**	(0.000)***	(0.006)***	(0.000)***
Singapore	1.050	0.090	0.585	-0.376	-0.372	-0.362	-0.397
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***

The table shows the results of a GARCH estimation of the regression $R_t = \beta_1 + \beta_2 UB_t + \beta_3 UA_t + \beta_4 DB_t + \beta_5 DA_t + \varepsilon_t;\ \ \varepsilon_t \sim N(0, V_t); V_t = \alpha_1 + \alpha_2 UB_t + \alpha_3 UA_t + \alpha_4 DB_t + \alpha_5 DA_t + \alpha_6 V_{t-1} + \alpha_7 \varepsilon_{t-1}^2 + \eta_t$. The dependent variable is the variance of the return of each index and the indicator variables UB for the period before an upward movement, UA for the period after an upward movement, DB for the period before a downward movement and DA for the period after a downward movement through a barrier. V_{t-1} refers to the moving average parameter and ε_{t-1}^2stands for the GARCH parameter. A period is defined as 10 day duration. The first line corresponds to the coefficients of the dummy variables under analysis and the P-value under parenthesis shows the marginal significance of these statistics. Under study are the 10-barrier for South Korea, the 100-barrier for China, Taiwan and Singapore and the 1000-barrier for Hong Kong and Japan.

Significant at 1 percent level ***

Significant at 5 percent level **

Significant at 10 percent level *

Finally, Table 12 shows the results for the four hypotheses (see Section 3.1 4.) under test. We would expect that after crossing a barrier the restraints of mean and variance would be softened. In fact, accordingly with our results, there are evidences that psychological barriers indeed exist in Asian stock markets, either for conditional mean or conditional variance effects. Two indexes reject the hypothesis of no differences in conditional means before and after an upward crossing at one percent significant level. While one index accepts the possibility of substantial changes happening in conditional means before and after a downward movement at five percent significant level. Thus, this findings support the existence of psychological barriers in South Korea and Taiwan. In both equity markets significantly higher returns after crossing a psychological barrier in an upward movement are found. However, the effects on conditional returns in the post crossing period as part of a downward movement suggest a substantial decrease. These findings support Cyree *et al.* (1999) since upward crossings through barriers tend to have a positive impact on the conditional mean return while downward crossings are mainly undetermined. The last happens because the lack of significant results in a downward movement prevents us to take conclusions.

Regarding, the results of the variance analysis, they support the previous findings of being more significant concerning conditional volatility of stock markets. All indexes under test show signs of crossing psychological barriers, except Singapore. The third restriction, which tested the difference in the conditional variance before and after an upward crossing of a barrier, is rejected for three of the six indices- South Korea and Hong Kong at one percent significant level and Japan at ten percent significant level. Concerning the dynamics of the volatility in the fourth hypothesis, the inexistence of changes in conditional variance before and after a downward movement, it is rejected for China, South Korea, Taiwan, Hong Kong and Japan at ten percent significant level for the last and one percent significant level for the remaining ones. The effects of these changes in volatility are not uniform. South Korea and Japan's market are more volatile after crossing a barrier from an upward movement. Whereas Hong Kong shows the opposite, i.e., volatility decreases after a psychological barrier is breached from an upward crossing. China and South Korea show lower volatility after crossing a barrier from a downward movement and Taiwan, Hong Kong and Japan stock markets are more volatile after a downward crossing of a psychological barrier. South Korea, Hong

Kong and Japan present consistent significance in the case of both upward and downward movement.

Overall, evidence suggests that there are significant effects in terms of returns in stock market indices around barrier points and volatility is also significantly affected in most of the markets under analysis. In order to run a deeper investigation we are going to focus on South Korean and Taiwanese results once psychological barriers were consistently found in the analysis of conditional returns and variances. In line with Cyree *et al.* (1999), Taiwan showed that conditional returns increase as conditional variances decrease. This may be characterized as an “aberration” in the equilibrium risk-return that is possibly a reflection of higher technical trading around presupposed barriers. Also, as pointed by Aggarwal and Lucey (2007), the positive relationship between return and risk, used in many financial models, may suffer some adjustments. Variance is used as a proxy for risk and its changes should be associated with changes in expected returns. Nevertheless our findings suggest that these variations in the correlation of risk-return near support or resistance levels may be biased in the case of the Taiwanese equity stock market. Though, this relationship is maintained in the case of South Korea once an increase in returns is followed by an in increase in volatility. Finally, comparing emerging markets with developed markets, the presence of barriers is consistently appearing in two of the emerging market while for the other category the findings are inconclusive.

Table 12 - Barrier hypotheses tests

Series		H_1	H_2	H_3	H_4
China	Chi-square	0.004	0.096	0.055	14.606
	P-value	0.944	0.756	0.813	0.000***
South Korea	Chi-square	8.540	0.910	7.987	161.063
	P-value	0.003***	0.339	0.004***	0.000***
Taiwan	Chi-square	37.151	4.532	0.939	18.627
	P-value	0.000***	0.033**	0.332	0.000***
Hong Kong	Chi-square	1.688	0.060	2.171	40.135
	P-value	0.193	0.805	0.000***	0.000***
Japan	Chi-square	0.019	0.439	2.237	3.285
	P-value	0.888	0.507	0.072*	0.069*
Singapore	Chi-square	0.042	1.502	0.337	2.025
	P-value	0.837	0.220	0.561	0.154

The Table shows the results for a Chi-square test for four hypotheses. H_1: No difference in conditional means before and after an upward crossing. H_2: No difference in conditional means before and after a downward crossing. H_3: No difference in conditional variance before and after an upward crossing. H_4: No difference in conditional variance before and after a downward crossing.

Significant at 1 percent level ***

Significant at 5 percent level **

Significant at 10 percent level *

5. Conclusion

In this dissertation we investigated whether or not psychological barriers exist. Using the daily stock price indices of six Asian stock markets, China, South Korea, Taiwan, Hong Kong, Japan and Singapore we find that this bias is present in some of the mentioned equity markets. Under the expectation of M-values not following a uniform distribution in the presence of barriers, our results show that all indices rejected the null hypothesis of uniformity at specific levels. China and Japan were the stock markets that accepted more often uniformity meaning that psychological barriers were hard to find. On the other side, South Korea consistently showed at the 10-level support or resistance levels; Taiwan presented regularly barriers at the 100-level; Japan at the 1000-level and Singapore displayed psychological barriers at the 100-level. Then, using conditional effects of mean and variance on index returns we discovered that only Taiwan and South Korea showed consistency with the previous findings having barriers at 100-level and 10-level, respectively. With this test we find other interesting conclusions that are worth mentioning. First, upward crossings through barriers tend to have a positive impact on the conditional mean return while downward crossings are mainly undetermined. Second, the relation between risk and return after breaking a barrier, in the Taiwanese index was contrary to the expected, once conditional returns increased as conditional variances decreased. However, for South Korea the traditional positive relationship was maintained. These findings can potentially be used by investors to build more profitable strategies when in the presence of potential barriers. Regarding the comparison between emerging and developed areas, we conclude that two of emerging markets under test – Taiwan and South Korea, present consistent evidences of psychological barriers while developed stock markets do not. This is in line with Woodhouse *et al.* (2016) statements about investors that work in developed markets being better informed and more rational. Concerning the impact on EMH (efficient market hypothesis) we believe that, since psychological barriers are considered an anomaly, markets are not efficient. Besides this, since prices are also a reflection of investors' moods and feelings we can say that when investing, individuals do not act in a full rational way.

Further investigation must be conducted on this matter, once high frequency trading performed by computerized devices is increasing and so it would be curious to check if psychological barriers were indeed a behavioural bias or if they would disappear. Besides, the utilization of other detection methods to check the existence of barriers in Asian markets would be interesting because most of them are based on the assumption of uniformity.

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